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TECHNOLOGY, ENVIRONMENT, AND DEVELOPMENT: OPTIONS FOR CANADA AT UNCED AND BEYOND

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Responsibility for the views expressed in this document, of course, rests with the author. While the report draws on the experience of IDRC, it does not necessarily represent the views of IDRC or its Board of Governors.

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Executive Summary

Debate on transfer of environmentally sound technologies has focused on financial, institutional and legal mechanisms by which technologies currently applied in the North can be transferred to developing countries. **Canada can provide international leadership in presenting a wider perspective, concentrating on the role of technology in promoting sustainable development, and the potential of international cooperation in fostering this role.**

Such a perspective should be based on the following insights:

- it is impossible to identify in advance an exhaustive list of environmentally sound technologies; instead, identification of such technologies will be an ongoing process;

- debate must deal with the ways in which the entire vector of technological change can be altered in the direction of greater environmental sustainability; in addition to technology transfer, this implies support to the creation of new scientific knowledge in developing countries, and to incremental improvements to technology over time;

- the availability of relevant technologies and the degree of concentration of supply vary widely across sectors and applications; it is a mistake to assume that developing countries cannot simply pull the necessary technologies 'off the shelf';

- the ultimate goal of international action should be to enhance the capabilities of developing countries to select, import, assimilate, adapt and create the relevant technologies. Concern with the economic and environmental efficiency of a given technology must be matched with a concern for its integration into the local productive structure, the conditions by which it is acquired, and the extent to which hardware imports are accompanied by effective transfers of knowledge and capabilities.

- there is increasing recognition that environmentally sound technologies can also result in increases in economic efficiency, and that transfer of technology can play a role in enhancing the competitiveness of technology suppliers as well as recipients. There is thus scope for 'win-win-win' solutions which meet the development needs of the Third World, the commercial needs of technology suppliers, and the environmental needs of the planet.

In terms of concrete Canadian action, this report suggests a 'two-track' approach, in which efforts to reach a consensus among the relevant actors are balanced with more immediate, independent actions. The report outlines a set of finite, concrete actions which should be pursued regardless of the success in securing a comprehensive multilateral agreement, or the precise form of that agreement.

1) Clarifying the Rules of the Game

Canada should reaffirm its position that in the case of commercially-developed, proprietary technology, recognition of intellectual property rights is essential to the continued development of much-needed technologies. At the same time, however, Canada should resist pressures to force developing countries to unilaterally extend property rights into new and controversial areas, particularly regarding living organisms.

Canada should reaffirm that in the case of privately-owned technologies, market rates should form the basis for compensation to the owners of technology. On the other hand, developing countries should be provided with concessional financing in order to allow them to make such purchases, and should be assured that such financing would be additional to existing commitments for development assistance. Canada should also press for renewed discussions on some form of code of conduct on technology transfer to guard against abuses of strong market positions.

2) Increasing the Supply of Technology from Abroad

Canada should support initiatives along the lines of the multilateral fund established under the Montreal Protocol, in which negotiations between technology suppliers and recipients are separated from financing of developing country purchases. At the same time Canada should ensure that developing country concerns about the governance of such institutions receive due attention.

Given the difficulty of reaching agreement on a comprehensive multilateral fund, attention should also be given to more limited steps to increase the supply of technology. A variety of actions are possible, depending upon the type of technology in question (proprietary technologies; public domain technologies; 'emerging' technologies and pre-commercial research; and, 'soft' technologies or know-how). Failure to resolve some of the broader issues on the table (intellectual property issues, for example) should not forestall unilateral actions by Canada in this regard.

3) Promoting Adoption and Assimilation of Technologies

Adoption of environmentally sound technologies is limited both by distorted price signals and by non-market barriers. Canada can promote technology adoption in a number of ways: financial and technical assistance for specific aspects of policy reform (regarding investment criteria, for example, or regulatory standards); funding of demonstration projects illustrating the technical and economic efficiency of environmentally-sound technologies; financial and technical assistance to promote technology-sharing arrangements among developing country firms to overcome the high capital costs of many technologies; or, assistance to improve the technical expertise of local and regional lending institutions in developing countries.

Alongside technology adoption, attention must also be given to the assimilation of technologies. Canada should ensure that effective assimilation of imported technology is an explicit objective of any initiatives in the field of environmentally sound technology transfer -- by building adequate training into ODA-funded projects, and by providing incentives to promote such involvement by private sector suppliers.

4) Improving Needs Assessment and Technology Choice

An adequate basis in 'the science of the environment' is crucial if developing countries are to make adequate assessments of their technological needs. The kind of collaborative needs assessments carried out under the Montreal Protocol are a potentially important tool of capacity-building. Canada should support the application of similar exercises in the follow-up to UNCED, and should give particular attention to the methodology to be used in such assessments.

There is also a need for better access to information on the range of technological options available to developing countries. Canada should support efforts to improve coordination among the various inventories, databases and information services now in operation, either by the creation a single clearing house and information network on environmentally sound technologies or (perhaps more fruitfully) by instituting more effective interchange among sector- and location-specific inventories.

In addition, careful thought needs to be given to the design and implementation of information systems to ensure that the appropriate clients are in fact reached, and that the appropriate support is available to promote diffusion of the information within supplier countries. There is also a need for the design of improved teaching materials, manuals, and assessment criteria to permit the more effective evaluation of technology alternatives.

5) Strengthening Indigenous Innovative Capabilities

Canada can pursue a number of independent actions to strengthen developing countries' innovative capabilities, ranging from support to twinning programs, to enhanced scholarship support to developing country students, to the kind of research support provided by IDRC.

Given the economies of scale associated with scientific research and the limited resources available to most developing countries, however, some form of collaborative effort in this area is essential. Canada should actively support the UNCED Secretariat proposal for the establishment of regional capacity-building programs, bringing to bear its own experience (via IDRC and other institutions) in strengthening research networks in developing countries. Canada should also use its 'convening power' to bring diverse views and actors to the table, in order to develop concrete avenues of action.

I. Introduction

The debates leading up to the United Nations Conference on the Environment and Development (UNCED) have given new life to the subject of North-South technology transfer. To a large extent, however, this re-examination has been narrowly bounded, focusing on the financial, institutional and legal mechanisms by which technologies currently applied in the North can be transferred to developing countries. Other issues -- the nature of developing country technology needs, the role of developing country research systems or the factors affecting the adoption of technology -- have been downplayed. **Canada can and should provide international leadership in presenting a somewhat wider perspective, concentrating on the role of technology in promoting sustainable development, and the potential of international cooperation in fostering this role.**

The agenda facing the international community is an increasingly broad one. Public attention and political action in the North have focused on the 'global change' issues: ozone depletion, greenhouse warming, deforestation and the erosion of biodiversity. But alongside these 'live' issues are a series of more 'latent' environmental problems which have important impacts in developing countries, but which have attracted far less international attention -- either because they do not directly affect industrialized countries (desertification, for example), or because industrialized countries have already taken action to deal with them, however imperfectly, within their own borders (hazardous wastes, solid waste management, the urban environment, etc).[1]

Addressing this second set of issues is essential if developing countries are to be engaged in global environmental action. It also underlines the intimate connection between environment and development. Efforts by the world community to tackle current environmental threats must confront the realities of burgeoning world population, of disparities in resources and opportunities within and among nations, and of the crippling effects of poverty on the environment.

What role can technology play in a poverty-focused approach to environmental protection? Technology is by no means a panacea to environmental problems, nor should we exaggerate the ease with which technological solutions developed in one socio-economic context can be transferred to another.

Nonetheless, it is clear that any strategy to promote more sustainable patterns of development must draw upon technology -- understood here as the mix of knowledge, organizations, procedures,

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[1] I am grateful to Ashok Desai for suggesting the terminology of 'live' and 'latent' issues.

machinery and equipment and human skills which are combined to produce socially desired products. Environmental damage need not be an inevitable consequence of technological advance and economic growth. New technologies already available provide a wide range of responses to the recognized problems of the environment, and potential future technologies hold out the prospect of even more radical changes. What has until now been lacking is a commitment to pursue the host of social, legal and economic reforms needed to enable economic development, environmental protection and technological change to work toward a common end.

This too is beginning to change, and the UNCED conference is one indication of that change. Industrialized and developing countries now agree that given the tremendous disparity in scientific and technological resources between North and South, any environmental 'bargain' must include a commitment to provide developing countries with the financial and technological resources necessary to confront current environmental threats. Yet the precise nature of such a commitment has proven to be one of the most thorny and divisive debates in the lead-up to UNCED.

In part, this is because of the lack of a clear precedent for the current negotiations. The closest parallel, of course, is the Montreal Protocol on Substances that Deplete the Ozone Layer. The 1990 London amendment to the Protocol broke new ground in negotiations on international technology transfer, introducing three unprecedented amendments: an obligation of signatories to transfer the best available technologies on "fair and favourable" conditions to developing country Parties; the creation of a multilateral fund to finance the incremental costs to developing countries of compliance with the Protocol; and, a clear statement that the ability of developing countries to fulfil their obligations under the Protocol was dependent on the implementation of the provisions regarding financial cooperation and technology transfer.

There is little doubt that the Montreal Protocol experience will form at least an implicit backdrop to the UNCED debates, particularly those on climate change. The type of agreements reached in the ozone accord have set a bench-mark against which developing country participants will now judge subsequent agreements in other fields.

But the Montreal Protocol offers at best a limited precedent for the debates at UNCED. While the scientific evidence regarding climate change is strong, it has not yet attained the level of consensus which persuaded the Parties to the Montreal Protocol to take dramatic action on ozone depletion. Equally crucially, the Montreal Protocol succeeded in large part because of the limited nature of the problem under consideration, the narrow range of alternative technologies to replace chlorofluorocarbons (CFCs), and the resultant ability to predict and limit the financial

obligations resulting from the treaty. Even if we consider only the climate change debate, the sheer scope of the problems on the table, the range of technologies potentially at issue, and the uncertainty regarding costs may stall attempts to reach agreement on issues of financial and technological cooperation.

To a large degree, discussions on transfer of 'environmentally sound' technology have mirrored earlier debates about North-South technology transfer more generally, both in the gulf separating the Northern and Southern positions, and in the nature of the issues addressed.

Northern countries have stressed the following four points:

- the need to ensure adequate financial compensation to inventors, via developing country recognition of intellectual property rights;
- a conviction that as far as possible, technology should be provided on non-concessional (commercial) terms, with no across-the-board guarantee of concessional access;
- a desire to limit the range of technologies under consideration, in particular by de-linking the climate change convention from other issues under discussion at the Summit; and,
- a preference for working through existing institutions in order to channel funds to support technology transfer activities, particularly the World Bank's Global Environmental Facility (GEF).

Within the Northern 'camp', the United States has adopted the hardest line in terms of intellectual property rights and non-concessional access. Other countries, notably Japan and Germany, have taken a softer line -- perhaps reflecting their leading positions as suppliers of environmentally sound products, and the perception that the principal economic benefits lie in promoting emerging environmental industries.

The Southern position, conversely, has tended to stress the following points:

- the need to secure access to the latest available technology, including proprietary technology, without conditionality in terms of reform of Southern patent legislation;
- the importance of concessional transfers, with the North bearing the brunt of the costs of providing the relevant technologies;
- the need to consider the entire range of environmentally-sound technologies, not just those of relevance to global warming; and,
- the importance of channelling funding through new institutions which would ensure an adequate voice for the

developing countries in their constitution and operation.

The emerging Southern position also puts emphasis on the need to negotiate a trade-off between Northern access to Southern plant varieties and Southern access to the results of biotechnology research being carried out in the North. More generally, many developing countries look to UNCED as an opportunity not only to tackle crucial environmental problems, but also to jump-start stagnant flows of technology and capital.

There are, however, some emerging signs of a movement away from this North-South deadlock. In the first place, there is a somewhat tentative consensus emerging that intellectual property issues are not the key constraint to effective action. This is not so much the result of any softening of positions on the issue, but rather a recognition that many of the relevant technologies are not patent protected -- but instead involve public domain technologies or 'soft' technologies (managerial expertise, for example).

Second, there is an increased recognition in both North and South that any effective strategy must involve not only the transfer of technologies from North to South, but also the strengthening of indigenous Southern technological capabilities, through a variety of training and capacity building measures. In general this is a positive sign, although developing countries also worry that industrialized country support for capacity-building and 'technology cooperation' may serve to detract attention from the crucial issues of financing and concessionality. On these latter issues, as well as on the scope of technology transfer provisions, there is no indication of a narrowing of the North-South gap.

II. Bases for Action

Unlike the debates over financing and institutions -- which have quickly moved to the consideration of a relatively narrow range of options for action -- the technology transfer debate has not converged on an agreed-upon range of choices. Instead, debate has tended to concentrate on broad principles (intellectual property rights, concessionality, 'technology cooperation').

There is thus a need for concrete, specific proposals which would help to bridge the gap between North and South. Discussion of concrete actions, however, must begin with a clear understanding of the nature of the problem. In this regard, earlier research on issues of science, technology and development -- much of it supported by IDRC -- yields several important lessons of relevance to the current debates. The pages which follow identify five broad insights which should guide Canadian action.

1) Environmentally Sound Technologies

In the first place, it is important to stress that environmental "soundness" is a relative concept. There are multiple and often conflicting criteria of environmental soundness, and few technologies will be 'best' on all such criteria. Over time, judgements about environmental soundness will change, as a result of the development of improved technologies, or the accumulation of evidence about the effects of supposedly 'benign' technologies (viz. the example of CFCs). Moreover, the environmental soundness of a particular technology will in practice depend crucially upon the conditions under which it operates.

This by no means indicates that environmentally sound technologies do not exist. What it does suggest, however, is that it is impossible to identify in advance an exhaustive list of environmentally sound technologies, and thus to limit concessional financing to this list. Instead, identification of such technologies will be an ongoing process, which will itself demand significant effort. As will be discussed in the pages below, one of the crucial areas for action is the strengthening of the capabilities of developing countries to define their technology needs, and to assess and select among alternative technologies.

2) The Sources of Technological Change

Much of the scope for environmental improvement will come not simply from the application of existing technologies, but rather from the development of new technologies and practices suited to local conditions, and from the efforts to improve the efficiency with which technologies are operated. This last point is frequently overlooked, despite mounting evidence that much of the potential for improving energy efficiency or reducing resource use (in both North and South) comes from increased operating efficiency, routine maintenance, and relatively minor adaptations to existing plant and equipment.[2]

As a result, it is a mistake to reduce the debate over the linkages between technology and sustainable development to a much more narrowly-bounded discussion of North-South technology transfer. The debate must tackle not only the transfer of environmentally sound technologies, but rather the ways in which the entire vector of technological change (in both North and South) can be altered in the direction of greater environmental sustainability.

This in turn implies a need to address three separate sources of technological change: i) the generation of new knowledge through

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[2] For an excellent review of the evidence, see Martin Bell, "Continuing Industrialisation, Climate Change and International Technology Transfer". Science Policy Research Unit, University of Sussex, December 1990.

basic and applied research, and the strengthening of local scientific infrastructure; ii) the diffusion or transfer of new technologies both within and across national boundaries, and their incorporation in productive activities; and, iii) the process of incremental improvements to production systems over time.

3) The Market for Environmentally Sound Technologies

Early research on North-South technology transfer underlined the importance of examining the nature of the market for technology, and further suggested that developing countries faced systematic disadvantages, both because of a lack of information on technological alternatives, and because of the dominance of large, oligopolistic firms as technology suppliers. More recent studies have qualified this finding somewhat, arguing that the international market for technology is more competitive than early assumed.

What sort of preliminary observations can we make regarding the 'market' for environmentally sound technologies facing developing countries?

As the points raised earlier make clear, a range of relevant technologies already exists. In the case of greenhouse warming, for example, these would include:

- technologies to limit the use of CFCs
- energy conservation technologies
- technologies to improve the efficiency of carbon-based energy production
- non-carbon energy technologies (wind, solar)
- agriculture and forest-related technologies, to improve energy efficiency, reduce methane emissions, reduce deforestation, and increase agricultural output per unit of land

While the range of available technologies is impressive, it is not exhaustive. In many cases technologies to meet specific developing country needs either do not exist, are in the early stages of development, or will require substantial adaptation. In other words, developing countries cannot simply pull the necessary technologies 'off the shelf'.

In addition, the market facing developing countries is extremely diverse. As a general rule, there appear to be a wide range of alternative technologies available, and a substantial diversity of potential suppliers, many of which are small and lack overseas experience. This may complicate problems of technology assessment and choice, and may also mean that some up-front financing will be necessary to allow small, inexperienced suppliers to overcome some of the initial costs of international technology transfer activities. But it also suggests a relatively competitive

market, in which developing countries should enjoy relatively strong bargaining power with suppliers.

The availability of off-the-shelf technologies, and the degree of concentration of supply, will vary widely among sectors and applications. Just as it is impossible to pre-define a comprehensive set of environmentally sound technologies, so our knowledge of the technology market will have to develop in a gradual, iterative fashion.

4) Technology Transfer and Technological Capabilities

The ultimate goal of any international action in the field of environmentally-sound technology should not be to apply particular technological solutions, but rather to enhance the capabilities of developing countries to select, import, assimilate, adapt and create the relevant technologies. In large measure, moreover, this is a matter of enhancing 'generic' technological capabilities rather than pursuing actions related specifically to environmental technologies. In the absence of sustained efforts to build such capabilities, transfer of novel technological systems may result in only limited and short-term improvements.[3]

Nonetheless, technology transfer is crucial to current discussions for three reasons.

In the first place, of all the disparities between North and South, the disparity in scientific and technological resources is most acute. No matter how much effort is made to develop local capacities in the developing countries in the medium term there will be continuing need for technology transfer. This is particularly true in the context of current environmental debates, where the challenges facing the international community are urgent and immediate.

Second, a commitment to increase the flow of environmentally sound technology may be an important means of countering some of the other trends at work in the international technology market. Problems of indebtedness and the shift of industrialized country investment away from developing countries have meant that commercial flows of technology from North to South have stagnated or declined over the past decade -- with the exception of flows to some of the newly-industrializing countries of East Asia. Cutbacks in aid appropriations have had similar effects on the flow of publicly-financed technology and technical assistance. At the same time, 'high-technology' sectors with potentially important roles in supplying environmentally sound technologies (biotechnology, advanced industrial materials) have been subject to strong trends toward the privatization of research, which has in turn reduced the

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[3] Ibid., p. 32.

flow of public domain technology in such fields. Finally, the growth of collaborative arrangements between Northern firms have accelerated the sharing of pre-commercial research, but in ways which have largely frozen out developing countries.

Third, technology transfer and innovation are not polar opposites. Earlier literature on North-South technology transfer (and the experience of countries such as South Korea) illustrate that technology imports can help to strengthen indigenous technological capabilities. But the link between technology imports and technological capabilities is by no means automatic, and depends crucially on the local policy and institutional context, and on the specific terms and conditions under which technology is transferred. As a result, concern with the economic and environmental efficiency of a given technological solution needs to be matched with a concern for its integration into the local productive structure, the conditions by which it is acquired, and the extent to which 'hardware' imports are accompanied by effective transfers of knowledge and capabilities.

5) Pursuing Areas of Mutual Interest

There are increasing indications that the perceived trade-off between protecting the environment and encouraging economic growth and development is not as rigid as often assumed, and that the application of environmentally sound technologies can also result in increases in economic efficiency. Reductions in pesticide use as a result of the introduction of bio-engineered plant varieties, waste reduction due to computerized control of manufacturing processes, or decreases in energy consumption due to miniaturization are all examples of such a process.[4] It is not only through such radical innovations that economic and environmental objectives can be linked: in both industrialized and developing countries, incremental improvements to existing facilities can yield simultaneous economic and environmental benefits.

There is also growing recognition that technology transfer can yield benefits to suppliers far beyond the direct financial compensation involved in a given transaction:

- expansion of export opportunities for spare parts, auxiliary equipment, and related products or technology

- increased efficiency of the transfer process itself, as suppliers gradually learn to master the legal, managerial and technical challenges involved in successful transfer

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[4] See World Resources Institute, Transforming Technology: An Agenda for Environmentally Sustainable Growth in the 21st Century. Washington: World Resources Institute, 1991, pp. 1-3.

- enhanced competitive position of supplier firms vis-a-vis international competitors, particularly in cases where home markets are too small to permit economies of scale

- improving the productivity of input and component suppliers, as a result of the transfer of new generations of production technology

- two-way flows of knowledge, in which suppliers benefit from process or product adaptations pioneered by recipients.

Transfer of technology may thus play a role in enhancing the competitiveness of Canadian environmental industries, particularly in areas where Canada has an established reputation (remote sensing, for example, or waste-water management).

This does not mean that commercial advantage should be the key criteria in support to technology transfer. But it does suggest that there may be a Northern interest in such transfer quite apart from its contribution to resolving environmental problems. Initial attention should be directed toward exploring possible 'win-win-win' solutions -- that is, initiatives which meet the developmental needs of the Third World, the commercial needs of technology suppliers, and the environmental needs of the planetary ecosystem.

Such actions can help to increase the likelihood of longer-term, more comprehensive, and more costly measures -- both by demonstrating the potential for reversing environmental degradation, and by generating the income stream necessary to finance more far-reaching initiatives. Attention should be directed toward overcoming the barriers -- financial, informational and institutional -- to the realization of 'win-win-win' solutions.

III. Options for Action

The pages which follow set out some more concrete avenues for action, grouped around five broad objectives:

- clarifying the 'rules of the game' with regard to international cooperation in the transfer and development of environmentally sound technologies;

- increasing the supply of environmentally sound technologies from abroad;

- promoting the adoption and assimilation of imported technologies;

- improving needs assessment and technology choice; and,

- strengthening the innovative capabilities of developing

countries in the field of environmentally sound technology.

The options presented below are for the most part not dependent upon securing a comprehensive multilateral 'bargain' between North and South. Instead, they concentrate on finite, concrete actions which should form the content of any program (multilateral, bilateral or unilateral) to promote the transfer and development of environmentally sound technologies to developing countries -- and which should be pursued regardless of the success in securing a comprehensive multilateral agreement, or the precise form of that agreement. The options are thus directed not solely to the UNCED debates, but also, and perhaps more importantly, to the follow-up to the Conference.

The options also reflect a conviction that effective action must involve a number of different actors -- national governments, private sector firms, international institutions, etc. The costs of securing consensus among the various actors are likely to be prohibitive, and should not forestall immediate action by individual actors or smaller groups of actors. Indeed, there is considerable scope for developing new and innovative partnerships between a variety of actors -- NGOs, municipalities, professional associations -- in North and South. Moreover, the global environmental debate is still characterized by a considerable level of uncertainty, particularly regarding the Southern side of the equation -- itself a product of the unequal distribution of global scientific resources.[5]

Under conditions of such uncertainty, the most appropriate response is to hedge one's bets. While there may be efficiency losses because of insufficient coordination -- or even contradictory actions -- these are likely to be less important than the transaction costs of negotiating more broadly-based solutions, or the danger of investing too many resources in what may turn out to be a false lead. This suggests a 'two-track' approach, in which efforts to reach a broad consensus among the relevant actors (with regard to international conventions, for example) are balanced with more immediate and independent actions.

1) Clarifying the Rules of the Game

In the first instance, attention must be given to clarifying the 'rules of the game' -- the broad principles which should govern cooperation between North and South in their efforts to facilitate technology transfer and strengthen the technological capabilities of developing countries. The most important and contentious points are likely to be intellectual property rights and concessionality.

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[5] See, for example, Anil Agarawal, Global Warming in an Unequal World. New Delhi: Centre for Science and the Environment, 1991.

Canada should stake out a clear position on each of these issues, while at the same time searching for points of compromise between North and South.

The issue of intellectual property rights is perhaps the most intractable, bringing to the fore differing perspectives on the nature of scientific research, and the appropriate distribution of the benefits flowing from such research.

Canada should reaffirm its position that in the case of commercially-developed, proprietary technology, recognition of intellectual property rights is essential to the continued development of much-needed technologies. At the same time, however, Canada should resist pressures to force developing countries to unilaterally extend property rights into new and controversial areas, particularly regarding living organisms. Instead, support should be given to ongoing multilateral efforts to resolve this issue, and more generally to find a compromise between Northern and Southern positions on property rights.[6]

In any case, the fact that much of the relevant technology is not patent-protected means that failure to reach a comprehensive agreement on this issue need not stall actions on other fronts. More limited actions to transfer patent-protected technologies may also be possible (see below), and may be an important means of ensuring the flow of proprietary technologies in the short- to medium-term. Such actions may also serve as important 'confidence building measures', helping to overcome the mutual suspicion between North and South on this issue.

On the issue of concessionality, the challenge is to marry Northern concerns to recognize the commercial nature of most technology transfer, with Southern demands for favourable access. A compromise position is possible, resting on a distinction between the terms under which technology is purchased from a commercial supplier, and the terms under which financing is available to developing country purchasers. **Canada should reaffirm that in the case of privately-owned technologies, market rates should form the basis for compensation to the owners of technology. On the other hand, developing countries should be provided with concessional financing in order to allow them to make such purchases, and should be assured that such financing would be additional to existing commitments for development assistance.**

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[6] The progress which has been made in the past few years on the issue of 'farmers rights' suggests that what were once seen as intractable issues can in some cases be resolved. See Keystone Center, Final Consensus Report: Global Initiative for the Security and Sustainable Use of Plant Genetic Resources. Keystone, Colorado: The Keystone Center, 1991.

In essence, this is a recognition of the broader principle that Northern countries (as distinct from Northern technology suppliers) should shoulder the larger part of the burden of countering global environmental problems -- both by taking immediate action to reduce their own contributions, and by assisting developing countries to make the necessary adjustments. If developing countries are to compromise on the issues of concessionality and intellectual property rights, this sort of strong commitment by industrialized countries in the area of burden-sharing is essential.

Finally, it is essential to recognize that the imperfect nature of some segments of the technology market means that 'market rates' may be excessive, and may be accompanied by excessively restrictive conditions of transfers. **Canada should press for renewed discussions on some form of code of conduct on technology transfer to guard against abuses of strong market positions.**

2) Increasing the Supply of Technology from Abroad

A long-term response to the problem of technology flows to developing countries must deal with the structural factors which limit demand for imported technology in these countries, such as small effective market size, foreign exchange constraints, lack of infrastructure, and low levels of domestic investment. Ultimately, this must involve action to resolve the underlying problems (debt, protectionism, stagnant aid flows, ineffective macroeconomic stabilization) which limit both foreign and domestic investment.

There has been considerable discussion of the kind of multilateral fund required to promote increased technology flows. In light of the discussion above, **Canada should support initiatives along the lines of the multilateral fund established under the Montreal Protocol, in which negotiations between technology suppliers and recipients are separated from the financing of developing country purchases. At the same time, however, Canada should ensure that developing country concerns about the governance of such institutions (e.g., the GEF) receive adequate attention.**

Given the difficulty of reaching agreement on a comprehensive multilateral fund, **attention should also be given to more limited steps which can be taken to increase the supply of technology.** The appropriate actions depend crucially upon the type of technology in question: proprietary technologies; public domain technologies; 'emerging' technologies and pre-commercial research; and, 'soft' technologies or know-how.

In the case of **proprietary technologies**, intellectual property issues remain the most frequently mentioned barrier to transfer. As noted above, it is doubtful that any across-the-board agreement on IP issues can be reached at UNCED. Even in the absence of such an agreement, however, there may be considerable scope to increase

the transfer of certain types of proprietary technologies.

- in the first place, companies may be willing to transfer recently-developed technologies in cases where these do not represent part of their 'core' technological capabilities. In industries such as electronics and automobiles, the wide network of equipment and component suppliers involved (many without equity links) means that "sharing" technologies may be an essential part of a competitive strategy. One recent example is Northern Telecom's program to transfer a CFC-free component cleaning technology to electronics assembly operations in Mexico.

- second, there may be considerable scope for technology cooperation among non-competing users. This is the case, for example, with a newly formed network of utility companies in the United States, an experiment which deserves much closer examination.

- finally, there may be scope for the creation of specialized brokering services to mediate between the owners of proprietary technology and potential users in developing countries. One interesting example is a recently-created non-profit brokering service in the field of agricultural biotechnology, the International Service for the Acquisition of Agri-Biotechnology Applications (ISAAA), which has already mobilized proprietary technologies for application in Mexico and Southeast Asia.

For more widely available, public domain technologies, the barriers are likely to be less legal than informational, and to some degree financial. As will be discussed below, actions to improve the availability of information on technological alternatives, and on market opportunities, is essential. Barriers may be particulary high in the case of small, specialized firms with little or no international experience -- which are important in at least some segments of the market for environmental technologies. Canada should explore the possibility of creating a special fund to support the involvement of such firms in supplying environmentally sound technologies: possible mechanisms might include government funding of export development missions; improved provision of market information to less experienced suppliers; or, support to brokering services to match local technology needs with appropriate suppliers.

In the case of emerging technologies and pre-commercial research, much depends upon whether research is primarily based in the public or private sector. In the latter case, significant progress can be made by donor countries in funding research partnerships between developing countries and Northern researchers in university or public sector institutions. IDRC's cooperative research grants, involving Canadian and developing country

scientists, represent a key model in this regard. At a more ambitious level, multilateral efforts might be taken to fund pre-commercial research in specific areas, along the lines of the CGIAR system in the field of agricultural research (see below). In cases where basic and pre-commercial research has been largely or completely privatized, the barriers to transfer are much higher. Strategic partnerships in the fields of semiconductors, telecommunications and the like have in recent years begun to span national boundaries, facilitating the international flow of pre-commercial research, but this has not involved Southern countries. In the future, there may be scope for the participation of some Southern enterprises in such schemes, but the limited scientific capabilities of most Southern countries makes this a remote possibility at best.

Finally, in the area of 'soft' technologies and know-how, there are a wide variety of mechanisms to facilitate transfer. Such know-how tends to be fairly widely dispersed in most fields, although information on the availability of particular types of expertise is often poorly distributed. Twinning arrangements, involving long-term partnerships between Canadian and developing country institutions, may be particularly useful, and should be a priority candidate for development assistance funding; these may be particularly important in areas such as urban environmental problems, where a range of Canadian municipalities and professional associations have useful experience. This is also an area where there may be considerable scope for South-South transfers. In addition, action to reverse the South-North flow of trained professionals may be crucial in this area -- which ultimately depends on efforts to strengthen scientific research institutions in developing countries.

3) Promoting Adoption and Assimilation of Technologies

Barriers to adoption and assimilation of more environmentally sound technologies affect both imported and locally-developed technological solutions.

In the area of technology adoption, the key problem is the frequent lack of incentives for the application of more environmentally sound techniques; as a result, existing and readily available solutions, whether imported or locally-developed, may not be applied as widely as is desirable.

For the most part, recent debate has viewed this problem as one of 'market forces', focusing on distortions in factor prices (especially energy), on poorly developed capital markets, and on trade restrictions which militate against the import of

environmentally sound products and processes.[7] Re-orienting prices to redress the most glaring problems (particularly regarding energy prices) is urgently required. This, for example, is the intent of carbon taxes on fossil fuels, or more general taxes on energy use: in both cases, taxation would force energy users to internalize the social and environmental costs of energy use, altering the relatively profitability of 'clean' technologies.

It is also increasingly being recognized, however, that market-based reforms on their own may be insufficient to alter prevailing patterns of technology use. In addition, a variety of non-market measures may be needed:

- more traditional 'command and control' type regulations may be essential in fields where market-based incentives do not function adequately (e.g., pollution standards to ensure water quality). Because of the technical and administrative requirements of regulatory action they should be used selectively, and one potentially important area of cooperation between North and South is in the design of regulatory systems appropriate to the conditions and administrative capabilities of individual developing countries;

- there may be important financial or technical bottlenecks to shifting to cleaner technologies -- for example, due to the up-front investment costs of switching to new process technology, or the need for ancillary technological expertise. In such cases, public sector financial assistance, or publicly-funded R&D, may play an important role;

- as a recent report by the UNCED Secretariat notes, developing country governments can also have a considerable effect on technology adoption by the reform of investment criteria for private sector investments, and by the judicious use of procurement provisions in public sector investment.[8]

Canada and other donor countries can assist developing countries in promoting technology adoption in a number of ways:

- financial and technical assistance for specific aspects of

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[7] See, for example, Touche Ross, Global Climate Change: The Role of Technology Transfer. A Report for the United Nations Conference on Environment and Development, financed by the U.K. Department of Trade and Industry and the Overseas Development Administration. London: Touche Ross, 1991.

[8] United Nations General Assembly, Preparatory Committee for the United Nations Conference on the Environment and Development, Report on the Transfer of Technology. A/CONF.151/PC/52. 8 July 1991.

policy reform (regarding investment criteria, for example, or regulatory standards). One interesting example is Dalhousie University's project on Environmental Management Development in Indonesia (EMDI), which provides a range of advisory services to the Indonesian Ministry of State for Population and the Environment;

- funding of demonstration projects illustrating the technical and economic efficiency of environmentally-sound technologies might help to overcome some of the non-financial barriers to technology adoption;

- financial and technical assistance to promote technology-sharing arrangements among developing country firms, as a means of overcoming the high capital costs of many of the relevant technologies;

- assistance to improve the technical expertise of local and regional lending institutions in developing countries. Development banks and similar institutions play a key role in providing local funding for technology transfer projects (as well as providing assistance to local private sector R&D efforts in many cases). Yet such institutions frequently lack the necessary expertise to adequately assess the technical feasibility of investments.

Alongside technology adoption, attention must also be given to the assimilation of technologies. It is now widely accepted that ensuring effective use is at least as important as promoting the initial adoption of technologies. Research has established that considerable effort must be expended in order to reach the operating parameters of a given technology -- if, indeed, these are ever reached. And since imported technology is often inappropriate to domestic conditions, a series of minor or major adaptations may be required to allow such technologies to function effectively in developing country markets.

Assimilation of imported technology is dependent upon the broad conditions facing local firms: degree of local competition, trade, monetary and fiscal policy, and the availability of trained personnel. At the same time, however, there are a variety of more limited, concrete measures which can be undertaken:

- in the first place, the feasibility of effective assimilation is also determined by the conditions under which technology is transferred, particularly the provision of long-term training and technical assistance services by the technology supplier. Canada should ensure that effective assimilation of imported technology is an explicit objective of any initiatives in the field of environmentally sound technology transfer -- by building adequate training into ODA-funded projects, and by providing incentives to promote such

involvement by private sector suppliers. In cases where such long-term involvement is not feasible (e.g., small supplier firms without the capacity to mount such after-sales efforts) alternative sources of technical assistance could be supported;

- second, there is almost universal agreement that an adequate supply of trained human resources is essential to effectively assimilate new technology and engender ongoing performance improvements. As a result, attention should be given to both incentives for on-the-job training, and more effective training of engineers, scientists, and technicians;

- finally, the development of technological capabilities is often the result of idiosyncratic firm-level factors, usually related to the personality and interests of management. As a result, management training and demonstration projects may have a decisive effect on firms' technical effort.

4) Improving Needs Assessment and Technology Choice

Sound technology choice is the sine qua non of any strategy for international technology transfer. Unless developing countries are able to make informed choices among the various technological options open to them, efforts to promote international technology transfer risk becoming overwhelmingly supplier-driven, geared more to transferring available technological solutions than to responding to the needs of developing countries. Yet at the same time, developing countries typically face severe disadvantages in terms of the information available to them, and their technical capacities to assess needs and evaluate particular technologies.

In the first place, an adequate basis in 'the science of the environment' is crucial if developing countries are to make adequate assessments of their technological needs. As such, the acquisition by developing countries of relevant scientific knowledge regarding environmental issues should be seen as an essential counterpart to any action on technology transfer. Given the impossibility of defining universal standards of environmental 'soundness', needs assessments will have to be explicitly geared to particular sectors and geographic locations.

One possible point of entry in this area may be via the needs assessments which will have to be carried out as part of both the specific conventions signed at Rio, and the broader 'Agenda 21' document. If properly designed, country-level needs assessments can themselves be an effective way of building indigenous capabilities. The experience of the Montreal Protocol may offer important lessons in this regard. Under the Montreal process, industrialized countries volunteered to collaborate with one or more developing countries in undertaking joint needs assessments, subject to a common framework developed at a workshop of

participating countries. Canada should support the application of similar exercises in the follow-up to UNCED, and should give particular attention to the methodology to be used in such assessments.

Such exercises are at best one element in a strategy of building needs assessment capacity, however, and must be accompanied by longer-term efforts to strengthen indigenous scientific research institutions (see below). In addition, needs assessment should not be focused exclusively on identifying possible technological solutions. As decades of experience in supporting research for development have shown, a successful intervention must start by identifying the felt needs of the local population, in order to ensure that chosen solutions are effectively implemented. While inventories of potentially-useful technologies are urgently required, it is crucial that needs assessment exercises not assume that solutions will be technological.

In addition to needs assessment, there is a need for better access to information on the range of technological options available to developing countries, and the performance characteristics of given technologies. This is now widely recognized, and there are a number of inventories, information services, databases and the like either in operation or in the planning stage. Canada should support efforts to ensure more effective coordination of the various initiatives, either by the creation a single clearing house and information network on environmentally sound technologies (as suggested by the UNCED Secretariat) or (perhaps more fruitfully) by instituting more effective interchange among sector- and location-specific inventories.

Sound technology choice will probably be limited less by the insufficient provision of information, however, than by the insufficient capacity of recipient countries to use the information available. Careful thought needs to be given to the design and implementation of information systems to ensure that the appropriate clients are in fact reached, and that the appropriate tools are available to promote diffusion of the information within supplier countries. In addition, there may be considerable room for the involvement of intermediary institutions which perform a brokering service -- particularly in fields of rapid technological advance where formal information services may not capture all the relevant information, and where the capacity of developing countries to evaluate various technological options may be limited.

In addition to support for the design and implementation of information services, donor countries like Canada can fund training support and personnel exchanges, both on a government-to-government basis and within productive enterprises. There is also a need for the design of improved teaching materials, manuals, and assessment

criteria to permit the more effective evaluation of technology alternatives.

5) Strengthening Indigenous Innovative Capabilities

While a capability to assess and select imported technologies is important, an effective response to global environmental threats ultimately must allow developing countries not simply to access the 'pool' of world technology, but also to create their own technological solutions. As a result, there is a clear need for support to the structures and institutions which foster innovation in developing countries.

Two points should be made regarding the types of capacity-building efforts required. First, the past two decades have witnessed a shift in the locus of technological effort away from formal research institutions, and toward the productive unit; as a result, any strategy to improve the technological capabilities of developing countries must involve action at this level, as well as broader-based support to national and regional research institutes.

Second, it is now accepted that innovations result not so much from single institutions, but rather from networks of institutions. As a result, considerable emphasis should be placed on efforts to improve the capabilities of technology users and equipment suppliers -- which in industrialized countries are increasingly recognized as an important source of innovation. In addition, ongoing efforts to provide effective linkages between research institutions and technology users in productive sectors are crucial, and should be a key focus of donor efforts to strengthen local systems of innovation.

Canada can pursue a number of independent actions to strengthen developing countries' innovative capabilities, ranging from support to twinning programs, to enhanced scholarship support to developing country students, to the kind of research support provided by IDRC. Given the economies of scale associated with scientific research and the limited resources available to most developing countries, however, some form of collaborative effort in this area is essential.

In this regard, there are two broad avenues of action. The first stresses the creation of new international and regional institutions charged with the furthering of environmental science, technology and policy. There are, of course, advantages to such an approach -- particularly the ability to transcend the disciplinary boundaries of many existing institutions in order to attack the problems from a more integrated perspective. Any such effort must learn from the strengths and weaknesses of the other such initiatives -- such as the international agricultural research centres -- already in operation. Specifically, there is a need to have greater participation by developing country scientists, policy

makers and users of the research results in these institutions than has often been the practice. Second, in a climate of severe resource constraints a new regional initiative is likely to be counterproductive, if it is at the expense of increasing the capacity of existing national institutions.

For this reason others argue for alternatives to the creation of new institutions. The UNCED Secretariat has proposed the establishment of regional capacity-building programs to support sustainable development in developing countries, which would not require the establishment of new central institutions, but would instead involve mechanisms for coordination and cooperation among existing institutions. **While remaining open to the possibility of participating in new regional institutions, Canada should actively support the UNCED Secretariat proposal, bringing to bear its own experience (via IDRC and other institutions) in strengthening research networks in developing countries. Canada should also use its 'convening power' to bring diverse views and actors to the table, in order to discuss concrete avenues of action.**

This sort of convening power should be exercised nationally as well as internationally. Efforts to strengthen the innovative capabilities of developing countries represent a key opportunity to broaden the basis of North-South dialogue on environmental issues, bringing to bear a more diverse set of views, and setting the stage for a variety of partnerships involving not only the federal government and its agencies, but also provincial governments, the private sector, the voluntary sector, and the academic community.